BMC Oral Health

RESEARCH

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Prevalence of rapid calculus formers and its associated factors amongst patients visiting a dental hospital: a preliminary investigation

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Abstract

Background This study focuses on the determination and classification of patients as rapid or slowcalculusformers-basedontherateofcalculusformationafteroralprophylaxis. It also aims to determine the factors that positively impact the formation and deposition of calculus in patients and identify the factors that accelerate or decelerate the deposition of calculus.

Methods The study was conducted in the Department of Periodontology, Dr Harvansh Singh Judge Institute of Dental Sciences and Hospital, Panjab University Chandigarh, India. We examined 51 patients after a month of the oral prophylaxis, recorded the amount of calculus present in the oral cavity, and then recorded a detailed history which was briefly divided into Age, Sex, Residence, Oral habits, and maintenance of oral hygiene.

Results An evident and meaningful link was found between age and the rate at which dental calculus forms. The average age of individuals differed significantly between the rapid and slow calculus formers, which could be ascribed to the decline in manual dexterity as age increases, resulting in less effective oral hygiene habits, including tooth-brushing. None of the other factors dietary and oral hygiene related could be identified distinctly, probably owing to the small sample of the study. The oral health status exhibited a significant difference between slow and rapid calculus formers.

Conclusions Within the limitations of the study, the data analyzed, identified age as a significant determinant that impact the rate of formation of calculus in patients and reported a significant difference in the oral health status of rapid and slow calculus formers.

Keywords Rapid calculus formers, Dental calculus, Diet, Oral hygiene, Age

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Background

Dental plaque is a biofilm composed of a complex microbial community and it is ubiquitously present in the oral cavity. It is the major etiological agent for dental diseases such as dental caries and periodontitis. Due to the constant presence of saliva containing mineral ions, the biofilm gets mineralized by the interaction of oral microbial plaque flora and components of oral fluids and forms hard yellowish-white deposits above or below the free gingival margin [1].

Various microorganisms attach to the tooth surface through a layer of acquired pellicles formed by salivary proteins. Pioneer bacteria include gram-positive cocci and filamentous bacteria. The plaque starts to get mineralized when the saliva is saturated with calcium and phosphate crystals [2]. Calculus formation begins with the deposition of kinetically favored precursor phases of calcium phosphate, which are gradually hydrolyzed and transformed into less soluble hydroxyapatite and whitlockite mineral phases [1, 2].

The process of mineralization involves metabolic activities of the bacterial colonies. It strengthens the attachment of non-mineralized biofilms to the tooth surface. It maintains proximity to the gingival tissues [2]. Dental calculus always harbors a living, non-mineralized biofilm that jeopardizes the integrity of the dento-gingival unit.

More calcium and phosphorus are found in dental calculus around the entry of salivary gland ducts than in other intraoral locations. Dental calculus development rates vary widely amongst individuals; however, they are often normal for a single person. Numerous factors influence the rate and quantity of calculus formation, including nutrition, particularly alkaline foods [3, 4] and sugars [5], genetic variations in salivary content [6], as well as age, race, gender, the presence of disease, and the subject's bacterial load [7, 8].

Though half of the mineralization happens in the first two days, the biofilm's mineralization process looks to be finished in 12 days [9–11]. The roughened surface of the calculus after mineralization offers a favorable environment for the deposition of fresh biofilm. Calculus may make it more difficult to follow the best oral hygiene procedures [12], which could accelerate the deposition of biofilm. Thus, the drainage from the crevicular area may be lessened [13]. Furthermore, the subgingival calculus can operate as a harmful bacterial product's secondary retentive site [14].

Two main factors were found in studies that examined the various factors influencing calcification in heavy and light calculus formers: (i) a difference in the biochemical composition of saliva between heavy and light calculus formers during early plaque development; and (ii) higher calcium levels, three times higher phosphorus levels, and lower potassium levels in the saliva of heavy calculus formers compared to that of light calculus formers [15]. Calculus formers typically deposit calculus every day in the range of 0.10 to 0.15% dry weight [11, 16].

Based on current understanding, dental calculus is more commonly observed in aged individuals, and in males compared to females. Further, the calculus formation is thought to be affected from hygiene habits, especially oral hygiene and general levels of education and social awareness etc [11, 17]. Several other factors including the increasing intake of sugary foods, inadequate brushing practices, poor oral hygiene, and low oral hygiene knowledge etc may influence the rate at which dental calculus forms, particularly in developing nations. Research aimed at elucidating such causative and risk factors on dental caries has been done extensively, and active treatment plans have also been developed for the condition [17–19]. However, calculus, even being a significant factor for oral and periodontal health, has not been studied in detail in this context. It is important to identify rapid calculus formers and associatedfactors-sothatsomespecificagentscanbeusedforprevention, customize supportive periodontal therapy or oral hygiene methods according to the patient. Presently, there is no such study done on the Indian population to decipher the how and why of this phenomenon.

Periodontitis is a destructive disease that causes bone loss and can be detrimental to the soft tissues. Though the major etiology is dental plaque, presence of calculus provides a consistent external location for the dental plaque to accumulate and perpetuate periodontal disease. Due to the rough surface of calculus in periodontal pockets, it leads to increased biofilm formation which worsens tissue inflammation, can lead to worsening of grading of the pocket, vertical bone loss, further attachment loss and ulceration of the junctional epithelium. The rate of calculus formation, and its composition, may differ depending on the intra-oral localization. The results of a recent study indicate that the presence of *S. mutans* bacteria, dental crowding, urea and phosphorus levels, and periodontal diagnosis are all strongly correlated with the rate of calculus development that each individual subject displayed [20].

Thus, it is important to determine the magnitude of rapid calculus formers and study associated factors, so that appropriate treatment strategies may be adopted for better patient outcomes in the future. Therefore, it is crucial to identify the extent of individuals who develop calculus quickly and investigate related factors. This enables the adoption of suitable treatment approaches to enhance patient outcomes in the future.

The objective of this study is to examine the varying rate of calculus buildup i.e. Slow and fast, amongst

individuals and investigate the factors linked to this phenomenon. This study aimed to assess the magnitude of rapid dental calculus formers among patients visiting the periodontal clinic of our hospital and further analyze the various factors associated with the formation of calculus in these individuals.

Materials and methods

This study was conducted in the Department of Periodontology at Dr Harvansh Singh Judge Institute of Dental Sciences and Hospital (HSJIDS), Panjab University, Sector-25, Chandigarh, after the approval by the Institutional Ethical Committee, and due consent of all the participating patients. It was an institution-based cross-sectional observational study.

Patients visiting the periodontal clinic, who had been treated with Phase 1 therapy in recent past (max 3 weeks before), and were then in the maintenance phase, with periodontal pockets $\leq$ 3 mm, a Silness and Löe plaque index $\leq 1^{10}$, and a Löe and Silness gingival index $\leq 1^{10}$, were screened. A thorough medical history was taken to exclude any individuals suffering from systemic diseases such as diabetes mellitus, hypertension, CVS disorders, kidney disease etc or conditions such as pregnancy/menopause etc or under systemic drug therapy for any reason to ensure the inclusion of systemically healthy individuals only preventing any confounding effects on the study observations .The study was carried out for 3 consecutive months. The nature and the course of the study were described to the participants and voluntary participation in the investigation was asked. Participants were enrolled in the study after obtaining written informed consent. A total of 51 patients agreed to be a part of this preliminary study.

A structured questionnaire prepared in English was developed from various previous similar published literature which had socio-demographic data, and factors associated with dental calculus. To guarantee the accuracy of the data, the questionnaire was first created in English, translated into Hindi or Punjabi by professionals, and then returned to English. The questionnaire was pretested in a different, comparable situation prior to the actual data collection to improve the validity and dependability of the data collecting instruments. Following the pre-test, the questionnaire was adjusted depending on the responses, and the final version of the data collection application was amended accordingly. (Supplementary file) A trained guide was ready to facilitate the training, which was provided to data collectors for one day prior to the actual data gathering activity. Every data collector received training on their roles in the study, including how to gather data, protect confidentiality, and guarantee genuine answers to questions. Lastly, to guarantee the questionnaire's completeness and provide additional clarification, the investigator closely adhered to the daily operations of data collection [17].

One dental physician with training performed the dental examination for each person that was chosen. A 10% random sample of individuals was reassessed on the same day to test the intra examiner agreement. Next, details about every individual were noted, including their demographic traits and past habits (Food Consumption Pattern, Dietary Habits and Practices Related to Oral Hygiene, including the details of the brushing method, frequency, type of toothbrush and tooth paste used). Other etiologies, such as dental crowding in the mandibular anterior teeth, were thought to contribute to the production of calculus [17, 20].

Volpe-Manhold index was used to identify the rapid calculus formers i.e. individual who can quickly develop significant amounts of calculus while maintaining good oral hygiene. One cannot label someone as a rapid former just because they demonstrate a high level of calculus at one time; this could be the result of years of buildup without preventive care, not a sign of rapid formation. The Volpe-Manhold index is a technique for quantifying calculus formation on lingual surfaces of lower anterior teeth utilizing a periodontal probe. This index measures several characteristics, including bleeding on probing, pocket depth, and attachment loss, to determine the degree and severity of gingival inflammation [20]. Rapid calculus formers were identified after more than eight weeks following their Phase I therapy, and because there were significant individual differences, only the participant who had accumulated a Volpe-Manhold index score of greater than seven was deemed an a rapid-forming subject under this study. Primarily factors associated with the food consumption patterns, dietary habits and oral hygiene practices were explored in relation to the rate of calculus formation, in addition to the demographic factors such as age, gender, education, and residential location.

The gathered data was cleaned, coded, and exported to SPSS version 20 for examination. Depending on the type of variable, descriptive statistics like frequency and percentage were employed. For every quantitative variable, the means and medians were determined, and the standard deviation was computed for measures of dispersion. Data normalcy was verified by the Kolmogorov-Smirnov measures of normalcy testing. Using the t-test, the means of two groups were compared for data that was normally distributed. Frequencies and proportions were used to define qualitative or categorical data. Fisher's exact test or Chi-square test, if appropriate, were used to compare the proportions. Every statistical test will have a

Table 1 Distribution of rapid & slow calculus formers in relation to demographic factors

	Slow formers (N)	Rapid formers (N)
Age	33[a]	18[b]
Sex		
Female	12	05
Male	21	13
Residence		
Rural	08	07
Urban	25	11
Marital status		
Married	25	16
Unmarried	08	02

[a] Mean Age = 40.45 years

[b] Mean Age = 49.94 years

Table 2 Association of slow & rapid calculus formers with age

	Slow formers		Rapid formers		
Age	**Mean**	**SD**	**Mean**	**SD**	***P* value***
	40.45	13.005	49.94	14.186	0.020

* Calculated by Independent T Test

significance level of α = 0.05 and be conducted with a two-sided design.

Results

The complete sample was divided into two groups according to the speed of calculus formation: Slow Calculus Formers 33(64.7%) and Rapid Calculus Formers 18(35.3%). The descriptive data analysis and results of the study are presented in Tables 1, 2, 3, 4, 5 and 6.

Discussion

Dental calculus forms when dental plaque, made mainly of calcium phosphate mineral salts, calcifies on natural teeth or restorations. It's then covered by a layer of unmineralized plaque. The distribution of calculus varies widely among individuals, teeth, and surfaces. Similarly rate of calculus deposition also varies among different individuals and can depend on numerous factors.

This study aimed to categorize patients as rapid or slow calculus formers based on their calculus formation rate post-oral prophylaxis. Conducted at the Department of Periodontology, Panjab University, Chandigarh, it involved examining 51 patients a month after prophylaxis. Factors such as age, sex, residence, oral habits, and oral hygiene maintenance were recorded.

Table 3 Association of slow & rapid calculus formers with demographic factors

	Slow formers (%)	Rapid formers (%)	*P*-value*
Sex			
Female	70.6%	29.4%	0.534
Male	61.8%	38.2%	
Residence			
Rural	53.3%	46.7%	0.273
Urban	69.4%	30.6%	
Marital Status			
Married	61.0%	39.0%	0.259
Unmarried	80.0%	20.0%	

* Calculated by Chi Square Test

Table 4 Association of slow & rapid calculus formers with dietary habits

	Slow formers (%)	Rapid formers (%)	*P*-value*
Diet			
Veg	54.5%	33.3%	0.147
Non-Veg	45.5%	66.7%	
Sweet Food Intake			
Yes	81.8%	77.8%	0.392
No	18.2%	16.7%	
Smoker			
Yes	15.2%	11.1%	0.373
No	84.8%	83.3%	
Quit	0.0%	5.6%	

* Calculated by Chi Square Test

Table 5 Association of slow & rapid calculus formers with oral hygiene habits

	Slow formers (%)	Rapid formers (%)	*P*-value*
Visiting dentist regularly			
Yes	6.1%	11.1%	0.607
No	93.9%	88.9%	
Frequency of brushing teeth			
Once	63.6%	36.4%	0.755
Twice	64.7%	35.3%	
After every meal	100.0%	0	

* Calculated by Chi Square Test

The analysis of data collected in this study indicates that factors such as gender, place of residence, marital status, dietary habits, frequency of sugary food consumption, smoking habits, dental visit frequency, and

Table 6 Association of slow & rapid calculus formers with oral hygiene status

Parameter	Slow formers		Rapid formers		
	Mean	SD	Mean	SD	*P* value*
Teeth present	28.758	3.9767	27.556	2.6618	. 063
GI	.6988	.15777	1.6278	.14429	< .001**
PI	.6909	.10282	1.4400	.23042	< .001**
DI	.5621	.12569	1.4783	.27171	< .001**
CI	.6084	.17227	1.6922	.22931	< .001**
OHIS	1.1664	.22570	3.1706	.42237	< .001**
PD	8.0100	.51319	9.6539	.48307	< .001**
CAL	.0030	.01741	1.8872	.54020	< .001**

*Calculated by Mann whitney test; ** significant at *p*-value ≤0.05

frequency of toothbrushing do not have a significant impact on the rate of dental calculus formation (Tables 2, 3, 4 and 5). However, a statistically significant correlation was observed between age and the rate of dental calculus formation. Rapid calculus formers had a mean age of 49.94 years, whereas slow calculus formers had a mean age of 40.45 years (Table 1). This correlation may be attributed to the decrease in manual dexterity with increasing age, leading to less efficient oral hygiene practices, particularly toothbrushing. Further in this study, no significant correlation was observed between the gender of the patient and the rate of calculus formation. However, contrasting findings exist in previous research. LA Christensen et al (1992) reported that males exhibited a higher susceptibility to developing calculus compared to females [21]. Conversely, Leva Kudirkaite et al [22] found that females tended to brush their teeth more regularly than males, suggesting a potential gender-related difference in oral hygiene habits. Yet, there is literature presenting a conflicting perspective, proposing that females may have a slightly elevated predisposition to rapidly developing calculus [23]. Our research similarly found no significant correlation between the patient's living environment, whether urban or rural, and the rate of calculus formation. Although limited studies have investigated this aspect, it's noteworthy that our study primarily comprised participants from urban areas, which could have influenced the outcomes.

Diet plays a significant role in dental calculus formation. Sugary and starchy foods provide a substrate for plaque formation, which can then calcify into calculus over time. Additionally, acidic foods and beverages can erode tooth enamel, making it easier for calculus to accumulate. Conversely, a diet rich in fibrous fruits and vegetables can help stimulate saliva production, which aids in the natural cleansing of teeth and reduces plaque buildup. In our study there seems to be a higher percentage of non-vegetarian diet followers among rapid calculus formers (66.7%) compared to slow calculus formers (45.5%). But the results suggest only a weak association between diet and the rate of calculus formation. However, previous research offers differing perspectives on this matter. For instance, Mohammad S Al-Zahranietal [24] indicated that overall diet quality is indeedassociatedwithcalculusdeposits. There is evidence suggestive of, that diets rich in carbohydrates and proteins may elevate calculus formation [23]. Additionally, Atarbashi et al [25] found that the patient's dietary patterns post oral prophylaxis positively influence the rate of calculus formation. Innocenti et al [26] also suggested that biodiversity and microbial functions can find an association with specific dietary habits such as a protein-rich diet.

In our study, Rapid calculus formers have a slightly higher percentage of individuals consuming sweet foods (81.8%) compared to slow calculus formers (77.8%),however it indicates a weak association between sweet food intake and the rate of calculus formation. In contrast a study by Kantorowicz M et al [27] found that Consuming crisps and cereal products was linked to a rise in dental caries and also correlated dental erosion with the intake of fruits, vegetables, meat, fish, and alcoholic beverages. Moreover, they also found that the consumption of sugar, sweets, and alcoholic beverages was associated with elevated plaque index(API) and bleeding on probing (BOP). These findings underscore the complexity of the relationship between dietary habits and calculus formation, highlighting the need for further research to elucidate underlying mechanisms and potential interventions.

Further effective oral hygiene practices such as regular brushing, flossing, and mouth rinsing help remove food particles and plaque from the teeth, preventing the build up of calculus. Consistent removal of plaque disrupts its mineralization process, reducing the formation of calculus over time. Conversely, poor oral hygiene habits lead to plaque accumulation, which can calcify into calculus if not adequately removed. But in our study, we found no statistically significant correlation between the oral hygiene habits of the patient and the rapidity of calculus formation post prophylaxis. This finding was inconsistent with a previous finding by Sissons' who noted heightened urea levels within bacterial plaque, leading to elevated pH levels caused by ammonia generated through ureolysis [28]. This process fosters the formation of calculus by enhancing the saturation of calcium phosphate in the plaque. D Souza et al [29] also found that bacteria may break down the salivary urea to ammonia resulting in a ureolytic pH rise that facilitates calcium phosphate saturation leading to more calculus formation.

Further our study suggested that dental crowding is not an appreciable factor in the rate of dental calculus formation after prophylaxis. However, In contrast Carla Fons- Badal et al [20] suggested that the presence or absence of dental crowding exhibited a significant difference in the rate of calculus formation between the two groups. In their study, the rapid calculus formers (64.7%) depicted more overcrowding in comparison with the group of slow calculus formers (35.3%).

Generally, smoking has been shown in numerous studies to increase the risk of calculus formation due to its impact on saliva composition, immune response, and oral microbiota. In our study, there is a lower percentage of smokers among rapid calculus formers (11.1%) compared to slow calculus formers (15.2%) but the Chi- square test value (1.975) suggests only a weak association between smoking status and the rate of calculus formation. A Research by Brian H Mullally [30] indicates that cigarette smoking poses a significant risk for the onset of severe, destructive periodontal disease in young adults. A notable prevalence of cigarette smoking was observed among young individuals diagnosed with aggressive periodontitis, and the use of tobacco notably amplifies the likelihood of periodontal destruction, particularly in young populations. This influence seems to correlate with the dose of tobacco used and remains independent of the levels of plaque buildup. However, a study by Jan Bergstrom [31] in which he studied the relationship between tobacco smoking and subgingival calculus formation, indicated a strong and independent association between tobacco smoking and supragingival calculus deposition.

The current investigation likewise found no direct link between tooth brushing techniques, snack frequency, consumption of carbonated drinks, and the rate of calculus formation. These results were supported by another recent investigation, who reported comparable outcomes [32]. There was statistically significant difference in the oral hygiene status parameters amongst the rapid and slow calculus formers, except for the no. of teeth present in the oral cavity (Table 6).

As the study findings identified a discrete group of rapid calculus formers in our study population, it is important that such patients should be made aware of their greater susceptibility to develop recurrence of periodontal disease. Further, they should be educated about the significance of maintenance of good oral hygiene by personal home care methods as well as professional oral health care interventions. Such patients should be recommended a customized oral health care plan and should be recalled more often as compared to slow formers [33]. A customized road map for day to day oral hygiene care procedures to maintain good oral hygiene and prevent rapid formation of calculus should be recommended (Supplementary information file 1).

One notable strength of our study lies in its comprehensive inclusion of patient demographics across various categories, encompassing individuals from rural and urban settings, as well as spanning both genders and dietary preferences, including both vegetarians and non-vegetarians. We made sure to undertake a thorough and meticulous history of our patients to ensure that our evaluation is as detailed as possible. Our data was also processed using software, and hence it can be trusted to be numerically accurate. Nevertheless, we had to deal with our fair share of limitations. As a result of diverse personal factors, a significant number of our patients did not present themselves for examination, thus rendering the study reliant on data collected from 51 patients. Owing to this restricted sample size, a multitude of factors may yield outcomes that deviate from initial expectations. We recommend advancing our research in this region with a significantly larger sample size to strengthen the reliability and validity of our findings.

The findings of the study has paved path for the translatory exploration of saliva, the biological fluid which is in constant contact with dental plaque, interacts with it to form calculus and can serve as a resource of biochemical information responsible for the differential rate of calculus formation in individuals. In this direction, our group is conducting another prospective investigation aimed at deciphering the distinctive metabolic profile of the saliva utilizing novel diagnostic technologies like FTIR, NMR, and ICP-MS to identify rapid and slow calculus formers. Similar investigations in future may lead to find appropriate target treatment agents and / or strategies, which may be adopted for prevention of rapid formation of calculus, concomitantly better patient outcomes for maintenance of oral health and hygiene and prevention of periodontal diseases.

Conclusion

Acknowledging the limitations imposed by our sample size on the comprehensiveness of our analyses, our findings indicate a significant correlation between age and calculus formation. It is important to recognize that our study's scope was constrained, precluding thorough examination of potential confounding variables such as oral habits, alcohol consumption, oral hygiene, and diet. We suggest that with a larger sample size, encompassing a more diverse range of participants and accounting for multi-faceted factors influencing calculus formation, correlations between these variables and calculus accumulation would likely emerge. Such correlations could offer valuable insights into the complex interplay between lifestyle factors and oral health outcomes. Therefore, future

research endeavors should prioritize expanding sample sizes to elucidate the nuanced relationships between age, lifestyle factors, and calculus formation, thereby facilitating more comprehensive preventive strategies and interventions aimed at promoting optimal oral health across diverse populations.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12903-024-04720-w.

Supplementary Material 1

Supplementary Material 2

Acknowledgements
None.

Informed consent statement
Participants were enrolled in the study after obtaining written informed consent.

Authors' contributions
Ankit Thakur (A.T.), Amneet Kaur Kooner (A.K.K.), Shreya Goel (S.G.), Rajni Jain (R.J.), Prabhjot Kaur (P.K.), Vishakha Grover (V.G.), Suraj Arora (S.A.), Gotam Das (G.D.), Artak Heboyan (A.H.), and Naseer Ahmed (N.A.) all contributed to the conception and design of the study. A.T. coordinated the research activities and participated in data analysis and interpretation, while A.K.K. played a key role in data acquisition and assisted in drafting sections of the manuscript. S.G. was involved in data acquisition and interpretation, contributing to the manuscript drafting. R.J. participated in data analysis and provided critical revisions. P.K. was involved in data acquisition and manuscript drafting. V.G. assisted in data acquisition, while S.A. contributed to data interpretation and manuscript drafting. A.H revised and edited final version of the manuscript. G.D. and N.A. secured funding for the study, and played key roles in study design, data interpretation, and critical revisions. All authors approved the final manuscript for publication and agree to be accountable for all aspects of the work.

Funding
The authors extend their appreciation to the Deanship of Research and Graduate Studies at King Khalid University for funding this work through Large Research Project under grant number RGP2/469/45.

Availability of data and materials
The data presented in this study are available on request from the corresponding author.

Declarations

Ethics approval and consent to participate
The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Dr Harvansh Singh Judge Institute of Dental Sciences and Hospital Panjab University Chandigarh, India (PUC/ERC/19/2023/69) and was conducted in agreement with the ethical standards of the declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 12 June 2024 Accepted: 8 August 2024
Published online: 16 August 2024

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